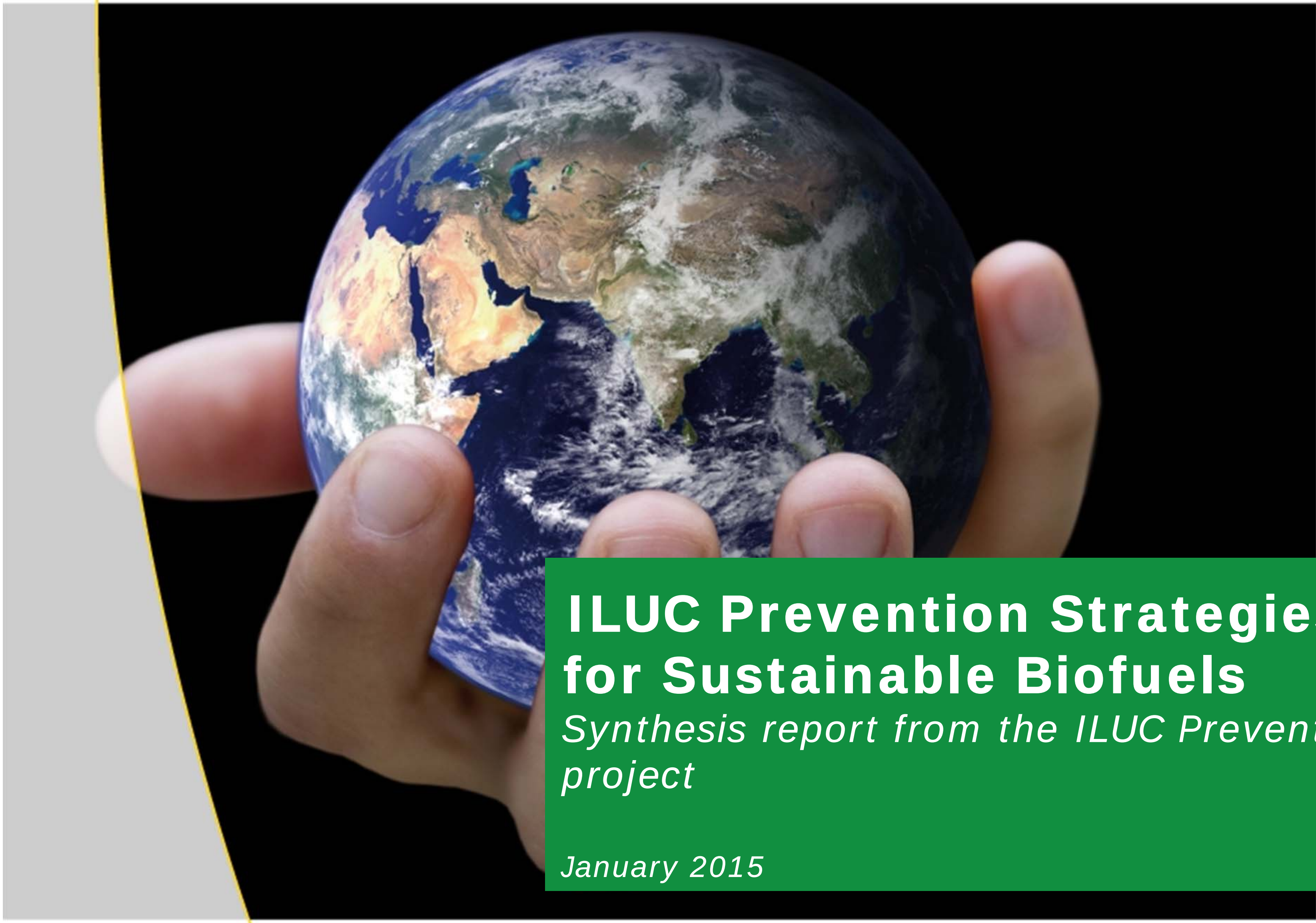
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Faculty of Geosciences

Copernicus Institute of Sustainable Development



ILUC Prevention Strategies for Sustainable Biofuels

Synthesis report from the ILUC Prevention project

January 2015

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Authors & Affiliation

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Disclaimer	The views expressed in this report are those of the authors and do not necessarily reflect those of the funding agencies.

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Non-technical summary (1)

Context: *-ILUC*	Increased demand for and use of biofuels over the past decade has led to closer scrutiny of the risks and benefits of their feedstock production. The debate has focused particularly on the concept of Indirect Land Use Change (ILUC). The risk of ILUC has so far been analyzed using aggregated, global economic models. These **models** have, however, **paid limited attention to measures that can counteract displacement**, such as improved agricultural efficiency.
- ILUC prevention	Because ILUC is the direct land use change (LUC) of another activity**, ILUC can be mitigated or even prevented when taking a sustainable approach to all crop production (whether for food, feed, fiber or fuel purposes).** This means: • Increasing productivity and resource efficiency in the production for all of these purposes, and • Appropriate zoning of land for all purposes.
- Benefits of ILUC prevention	Addressing ILUC in this way has the **additional benefits** of increasing the performance of the entire agricultural sector, reducing its pressure on land resources, and reducing GHG emissions in the biofuel supply chain.
Project aim	The *ILUC Prevention* project aimed at **providing insights into** • How ILUC (risks) can be mitigated by taking a sustainable approach to all crop production for all purposes; • How this can be quantified; and • How ILUC (mitigation) may be regulated.

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Non-technical summary (2)

Approach

Key ILUC prevention measures (e.g. above-baseline yield increases and cultivation of currently under-utilized land) were quantified for four case studies by assessing how much additional biofuel feedstock can be produced with **low risk of causing ILUC** (hereinafter also called low-ILUC-risk potential - Sometimes this potential is called ILUC-free as no displacement occurs. However, as this study did not account for market-mediated effects of the measures, it is here chosen to use the term "low-ILUC-risk"). The case studies were assessed for three scenarios in order to allow for uncertainties in the data used. The results are summarized and compared to biofuel targets for the case study regions in the table below.

Key results from case studies:
Large biofuel potentials with low risk of causing ILUC exist in all case studies

Feedstock	Case study location	Low-ILUC-risk potential as a percentage of the 2020 production target[a]
Miscanthus ethanol	Lublin province, Poland	140 – 410 %
Maize ethanol	Hungary	200 – 860 %
Rapeseed biodiesel	Eastern Romania	50 – 340 %[b]
Crude palm oil	North-East Kalimantan, Indonesia	120 – 180 %

a – The target is defined per case study as follows: *Lublin province*: Second generation bioethanol target specified in the National Renewable Energy Action Plan (NREAP); *Hungary*: bioethanol target specified in the Hungarian NREAP; *Eastern Romania*: the regionally-disaggregated biodiesel target for the NREAP; *North-East Kalimantan*: regionally-disaggregated production target projected in MIRAGE (target includes demand for all uses, not only fuel).

b - Rapeseed is part of a four-year crop rotation so that only one fourth of the land is used each year. Thus, more biofuels from other feedstocks could be produced each year without causing ILUC.

Non-technical summary (3)

Large biofuel potential with low risk of causing ILUC	The case studies show that **large amounts of additional biofuels can be produced with a low risk of causing ILUC**. In the high scenario, already 1.3% of the total energy use (or 13% of the renewable energy use) in road transport in the EU in 2020 could be met by low-ILUC-risk biofuels produced in only the three European case studies investigated in this project. Thus, **low-ILUC-risk biofuels produced from these three EU case studies alone could meaningfully contribute to sustainable biofuels in the EU in 2020**. Note that the three case studies cover only 6% of agricultural land in the EU, so the potential for all of Europe is substantial.
Key strategies to prevent ILUC: Yield increases and the use of under-utilized land	**Above-baseline yield developments** and **use of under-utilized land** are the most important measures for achieving ILUC prevention. In the Eastern European case studies, increased yields contribute in most cases to over 75% of the potential. In the Indonesian case study, use of under-utilized land contributes over 90% to the potential.
Generalizability of case study results **ILUC can be prevented**	**Other countries in Europe and elsewhere** have untapped low-ILUC-risk potentials that could be further explored and mobilized (e.g., mixed production systems in Western Europe such as double cropping, pasture intensification in Latin America, yield increases in Africa). Thus, **ILUC as determined in economic models is not an irreversible fact, but is a risk that can be mitigated and in many cases even be prevented**.

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Non-technical summary (4)

Policy recommendations	Substantial investment in the agricultural sector is essential to realize the low-ILUC-risk potential of biofuels as estimated in this study as well as to strengthen and enforce land use policies. The project's **key recommendations** to prevent ILUC and to promote sustainable production practices for all crops include: • Stimulating increasing productivity and resource efficiency in the agricultural sector through support and incentives schemes, including access to capital and technology, and capacity building. • Providing support and incentives for production on currently under-utilized land. • Promoting land zoning that excludes high carbon stock, high conservation value and important ecosystem service areas from conversion to any agricultural use, and incentivize forest maintenance.
EU legislation on ILUC mitigation	Given the potential to produce large amounts of low-ILUC-risk biofuels found in this study, EU legislation on ILUC mitigation should consider including more ways to mitigate ILUC than just capping all first generation biofuels. Implementing the measures proposed in this study and certifying low-ILUC-risk biofuel production is the key option proposed to mitigate ILUC. For this, a sustainable approach to all crop production for food, feed, fiber and fuel purposes is essential. **EU legislation on ILUC mitigation** should then consider allowing certified low-ILUC-risk biofuel production to contribute to the renewable energy target.
Next steps: Pilot projects	Pilot projects for demonstrating the approach, for assessing trade-offs between increasing data availability and quality vs. the time and costs to do so, and for monitoring and certifying ILUC prevention in the field are the next step to validate the concepts.

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Introduction (1)

Bioenergy	Biomass for energy (bioenergy) is an important option in making future energy supply more sustainable. The key supporting arguments are: • If produced sustainably, bioenergy can reduce greenhouse gas (GHG) emissions compared to fossil fuels. • Biomass is a versatile source for producing heat, electricity, liquid, solid and gaseous fuels. • Rural development associated with increased agricultural production. • Diversification of agricultural markets.
Bioenergy in the European Union	In the European Union, the main reason for support of bioenergy has been its policy on renewable energy for reducing GHG emissions. Two additional important motives are energy security and alternative market outlets for European farmers (Swinbank 2009).
ILUC questions the sustainability of bioenergy	Potential indirect land use change (ILUC) triggered by increased production of crops for biofuels became a central focus of attention and controversy as it could result in increased GHG emissions compared to fossil fuels (Searchinger et al. 2008) and thereby could contradict the original motives for bioenergy.

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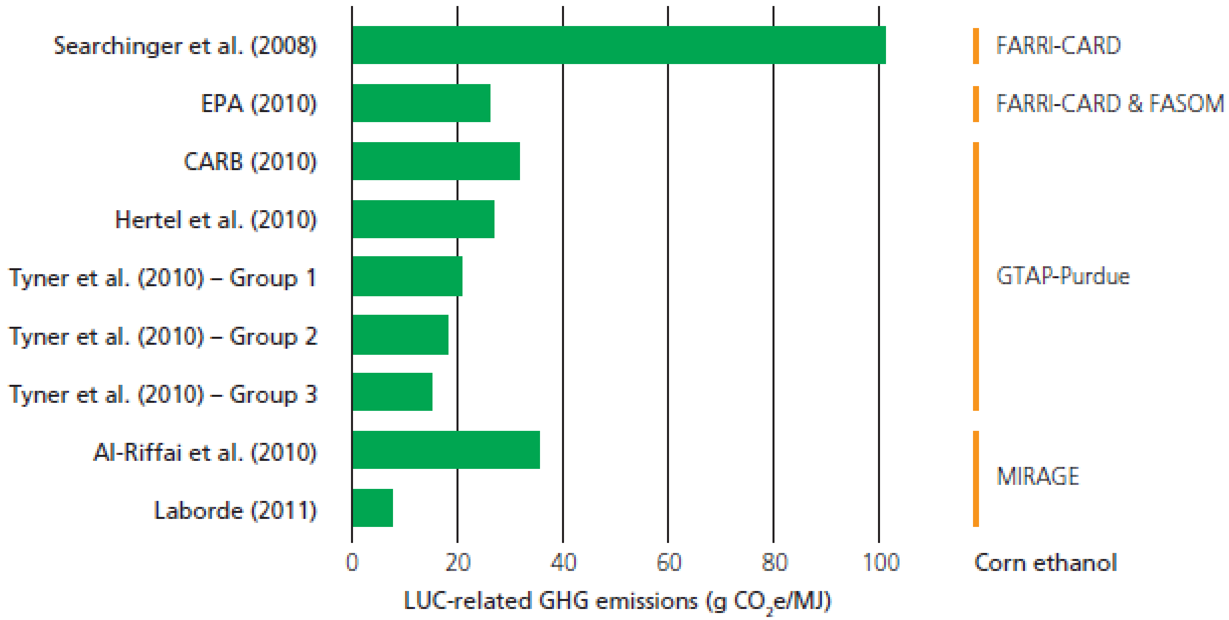
Introduction (2)

ILUC	Indirect land use change (ILUC) is land use change outside a feedstock's production area, which is induced by changing the use or production quantity of that feedstock (Tipper et al 2009). Two key underlying mechanisms for ILUC are: • In order to continue to meeting crop and livestock demand, a direct displacement of pastureland, cropland or crop use results in livestock or crops being produced elsewhere; or • the diversion of the crop to other uses causes higher crop prices, which results in more land being taken into agricultural production elsewhere (Tipper et al 2009, Searchinger et al. 2008).
Existing studies	Various studies have shown a large variability in the size of potential ILUC of different crops and in different settings (see example of corn ethanol next page); and results remain uncertain. However, results of all economic models are above zero and, therefore, ILUC must be addressed. But, existing studies have not yet looked into possible mitigation options and policies and their impacts.

Introduction (3)

Variation in GHG emissions from LUC across different studies - Example corn ethanol

(Adapted from Wicke et al. 2012)



Introduction (4)

ILUC prevention

As a result of uncertainties and shortcomings in existing studies on ILUC factors, more emphasis is now being placed on ILUC mitigation.

The different European Union government institutions consider the mitigation of ILUC in different ways. But a common theme is the cap on first generation biofuels (variation between 5 and 7% of transport fuels in 2020 towards the Renewable Energy Directive).

Simple cap on first generation as a solution?

However, a simple cap on first generation biofuels is not the solution to the ILUC problem:

- ILUC of biofuels is the direct LUC (DLUC) of another activity. Only if this DLUC is also addressed, can ILUC be prevented.
- Also second generation biofuels could cause ILUC if competition with food production takes place in the form of land (although effects are expected to be lower than for first generation biofuels).

Therefore, ILUC must be tackled by taking **a sustainable approach to all crop production (whether for food, feed, fiber or fuel purposes).**

Introduction (5)

ILUC prevention by taking a sustainable approach to all crop production	ILUC can be prevented if we take a sustainable approach to all crop production. This means: • Increasing productivity and resource efficiency in the production for all of these purposes; and • Appropriate zoning of land for all purposes. ILUC prevention is about i) finding synergies between agriculture and bioenergy, and clever modernization and sustainable intensification of agriculture in combination with producing biofuels, and about ii) steering any new expansion to currently under-utilized land.
Benefits of ILUC prevention	This approach to preventing ILUC can be beneficial for: 1) Farmers (especially smallholders) through support to achieve modernization of their production, 2) Land owners of under-utilized land that are able to earn income from new opportunities for their land, 3) Conservation of nature through reducing the pressure on land use by agriculture and forestry in general, and 4) Reducing GHG emissions from the agricultural (incl. bioenergy) supply chains.

Introduction (6)

ILUC prevention measures – multiple options are available that address prevention by taking a sustainable approach to all crop production

Mitigating or even preventing ILUC (and its effects) from conventional biofuels is possible in various ways (see e.g. Wicke et al., 2012 and Witcover et al., 2013):

- Increasing yields above-baseline (crops & livestock)
- Making more optimal use of agricultural land (e.g. multiple cropping)
- Using co-products more optimally
- Reducing waste and losses in the food and biofuel supply chains
- Better land zoning:
  - Excluding land with high carbon stocks & biodiversity values (also for non-biofuel production)
  - Using only under-utilized land for additional expansion

Open questions

More information is needed on how these measures' effects on ILUC prevention can be quantified and how much different measures can contribute to ILUC prevention. In addition, policy and governance options are needed that can help translate these technical measures to implementation and application in practice.

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Introduction (7)

Project aim

The "ILUC prevention" project aims at providing insights into the following questions:

- How can ILUC (risks) be mitigated by taking a sustainable approach to all crop production for all purposes?
- How can ILUC mitigation be quantified, and
- How may ILUC (mitigation) be regulated.

In assessing ILUC prevention measures, this project accounts for the various uses of land for food, feed, fiber and fuels production and thereby takes an integral perspective of agriculture and bioenergy as proposed above.

Project components

Develop a general methodology	• To quantify ILUC prevention measures
Conduct regional case studies	• To demonstrate, test and refine the methodology • To asses the availability and reliability of data that are required for the analysis • To investigate policy and governance options relevant in the specific settings
Define key parameters	• To translate into a methodological framework and monitoring and policy options
Propose governing framework	• To governing ILUC mitigation at EU level

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Approach (1)

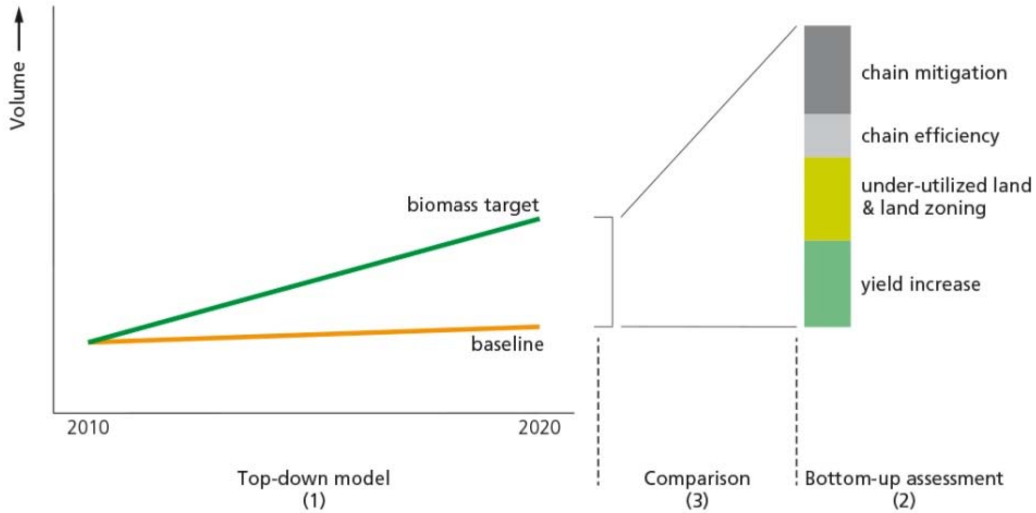
Quantifying ILUC prevention measures

The analysis focusses on assessing how much additional biofuels or their feedstocks can be produced with different ILUC prevention strategies (herein after also called **low-ILUC-risk potential**), and how this low-ILUC-risk potential compares to the biofuel feedstock target of that region (see figure next page). Sometimes this potential is called ILUC-free as no displacement occurs. However, as this study did not account for market-mediated effects of the measures, it is here chosen to use the term “low-ILUC-risk”.

Although the main focus is on how ILUC from biofuels can be mitigated, **ILUC from biofuels is the direct LUC of another product** and therefore all LUC needs to be addressed in order to mitigate ILUC from biofuels. Consequently, the analysis includes changes in production of all crops and also compares the final results from the bottom-up assessment with the model projections of all demand increases (not just for biofuels).

Approach (2)

General approach
(see also the appendix and Brinkman et al. (2015a) for more information)



The share of each measure is for illustration purposes only; the applicability and shares of the measures differ per region.

(1) Top-down (from economic models that assess LUC factors)	Determine biomass production baseline (without additional biofuels) and target (with a biofuel mandate) for each region. The difference between target and baseline is the amount of crop production induced by a biofuel mandate, which is the cause of LUC (including ILUC) in the models.
(2) Bottom-up (key activity of this project)	Analyze the low-ILUC-risk biofuel/feedstock production potential from key ILUC mitigation measures to determine how much biofuels/feedstocks can be produced without unwanted LUC
(3) Comparison	See next page

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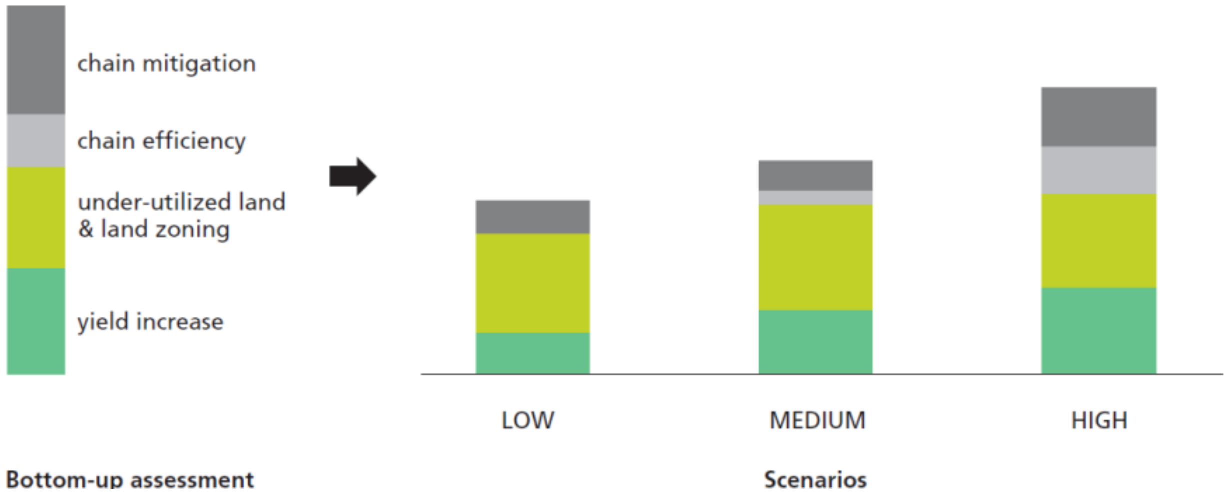
Approach (3)

(3) Comparison of top-down & bottom-up results

Compare top-down and bottom-up projections to assess whether enough biomass can be produced to fulfil targets or whether additional action is required to prevent ILUC.

Scenario approach in the bottom-up assessment

In the assessment of the low-ILUC-risk biofuel production potential from key ILUC mitigation measures, a scenario approach is taken in order to indicate uncertainty in projections (depends also on the level of investment) and effects on the results. Three scenarios for potential developments above the business-as-usual (*low*, *medium*, *high*) are applied.



Approach (4)

Bottom-up assessment of ILUC prevention measures	The assessment focuses on six measures to reduce the extent of ILUC, control the type of land use change, and limit GHG impacts of biofuels: 1) Increasing agricultural crop yield production efficiencies above the baseline level, 2) Using co-products from the biofuel supply chain as substitute for other products, 3) Reducing losses in the food and biofuel chains, 4) Producing biofuel feedstocks on under-utilized lands, 5) Land zoning in order to prevent the conversion of lands with high protection value 6) Reducing the GHG emissions of the biofuel supply chain.
Regional focus	ILUC prevention is assessed for specific regions because it allows • defining feasible and desirable biofuel production targets per region, • ranking ILUC mitigation measures and their importance for different regions, and • defining regional strategies for ILUC prevention.

Approach (5)

Four case studies

Regions were chosen that are expected to see large increases in production in the future.



Key results from case studies (1)

Overview of case study results
(Detailed results of the case studies are described on the following pages)

Large amounts of additional biofuels can be produced with a low risk of causing ILUC. In the high scenario, already 1.3% of the total energy use (or 13% of the renewable energy use) in road transport in the EU in 2020 could be met by low-ILUC-risk biofuels produced in only the three European case studies investigated in this project. Thus, **low-ILUC-risk biofuels produced from these three EU case studies alone could meaningfully contribute to sustainable biofuels in the EU in 2020**. Note that the three case studies cover only 6% of agricultural land in the EU, so the potential for all of Europe is substantial.

Feedstock	Case study location	Low-ILUC-risk potential as a percentage of the 2020 production target[a]
Miscanthus ethanol	Lublin province, Poland	140 – 410 %
Maize ethanol	Hungary	200 – 860 %
Rapeseed biodiesel	Eastern Romania	50 – 340 %[b]
Crude palm oil	North-East Kalimantan, Indonesia	120 – 180 %

a – The target is defined per case study as follows: *Lublin province*: Second generation bioethanol target specified in the National Renewable Energy Action Plan (NREAP); *Hungary*: bioethanol target specified in the Hungarian NREAP; *Eastern Romania*: the regionally-disaggregated biodiesel target for the NREAP; *North-East Kalimantan*: regionally-disaggregated production target projected in MIRAGE (target includes demand for all uses, not only fuel).
b - Rapeseed is part of a four-year crop rotation so that only one fourth of the land is used each year. Thus, more biofuels from other feedstocks could be produced each year without causing ILUC.

Key results from case studies (2)

Ethanol from Hungarian corn (Brinkman et al. 2015b)

Implementation of all the measures can provide 25-109 PJ (1.2-5.2 billion liters) per year of low-ILUC-risk bioethanol from Hungarian corn in 2020 (see figure next page). **This is 200% to 860% of the amount set in the National Renewable Energy Action Plan (NREAP) for 2020.**

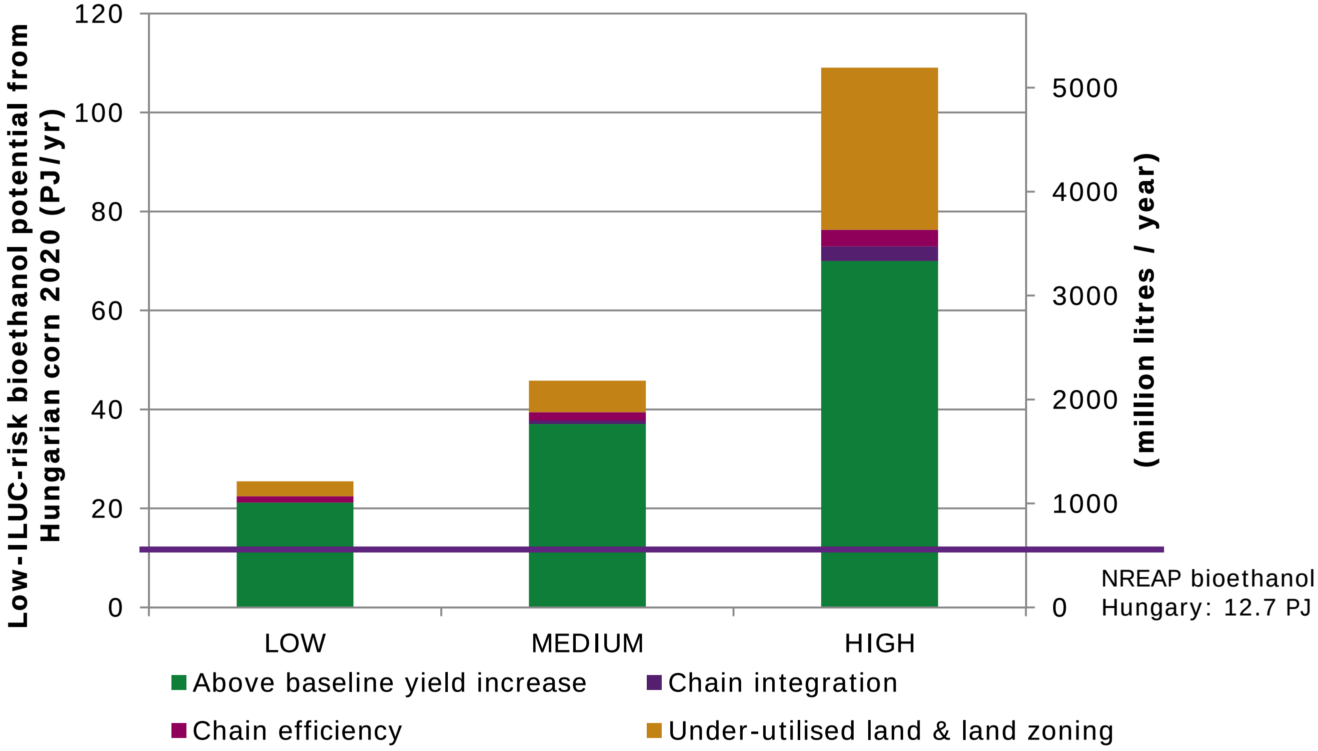
Increasing yields above the baseline is the most important measure for realizing the potential. Depending on the scenario, 49%-79% of the low-ILUC-risk potential comes from yield increases. Although the yield increases applied in this study are high (for corn: 18%-61% growth in comparison to the present), they are considered feasible given the currently high yield gap in Hungary.

The second most important measure is the use of abandoned agricultural land, which can provide additional low-ILUC-risk corn production for bioethanol ranging from 12% to 30% of the total low-ILUC-risk bioethanol potential.

Key results from case studies (3)

Ethanol from Hungarian corn

Figure: Production potential for low-ILUC-risk bioethanol from Hungarian corn: by ILUC prevention measure in the low, medium and high scenario in Hungary in 2020 compared to the National Renewable Energy Action Plan (NREAP) target for bioethanol in Hungary in 2020.



Key results from case studies (4)

Eastern Romania (Macroregion 2)
(Brinkman et al. 2015c)

The low-ILUC-risk potential of rapeseed biodiesel in Eastern Romania can reach 2-16 PJ (60 – 434 million liters) per year in 2020 (see figure next page). **This is 16-118% of the biodiesel target set in the National Renewable Energy Action Plan (NREAP) for 2020 *for the whole country* or 48-344% of the biodiesel target of the *NREAP disaggregated to the case study region*.** Thus, only in the low scenario ILUC cannot completely be prevented, indicating that larger efforts, such as those assumed for the medium and high scenario, are needed to prevent ILUC. However, assuming rapeseed is part of a crop rotation and only produced every four years, in the other years additional biofuels from other feedstock can be produced and compensate for this.

Above baseline yield development contributes the most to this potential (27% - 67%). This number not only includes yield increases for rapeseed production, but for all crops in Eastern Romania. Especially increased maize and wheat yields contribute much to the potential.

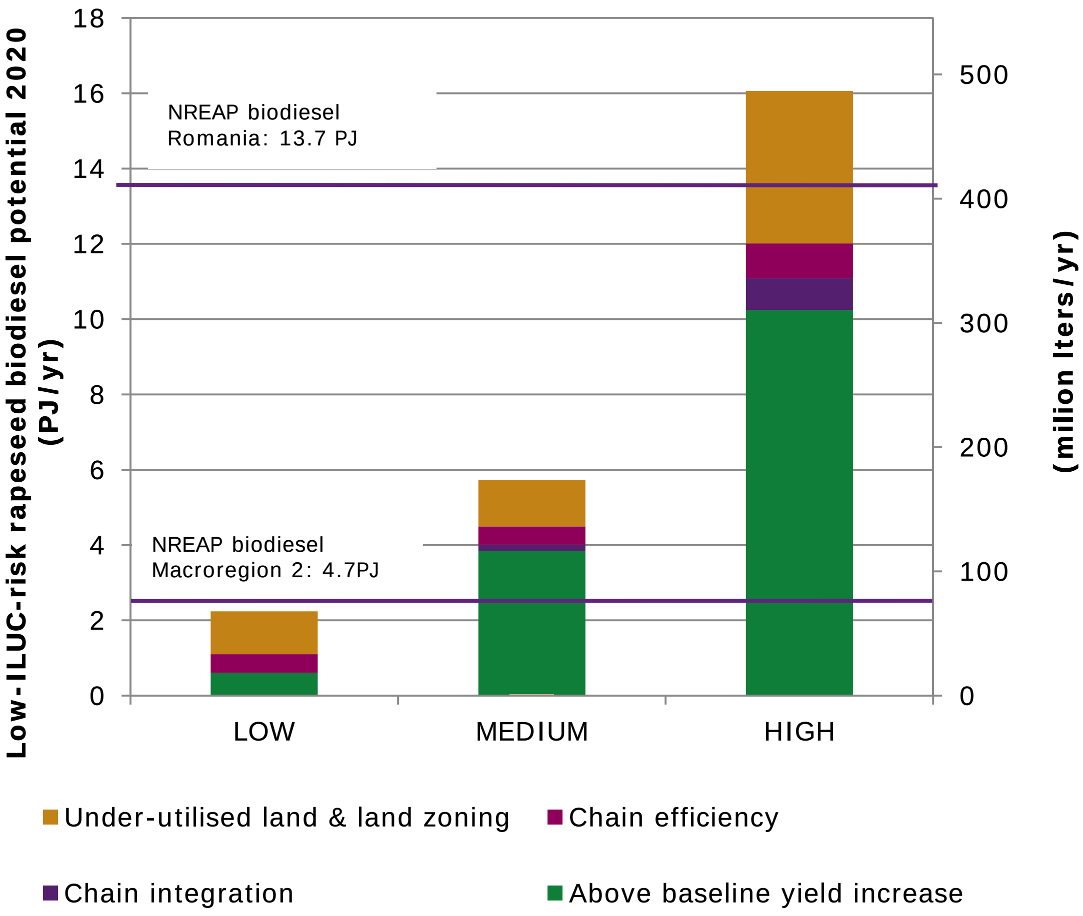
The second most important measure is the use of abandoned agricultural land, which can provide additional low-ILUC-risk rapeseed biodiesel ranging from 5% to 13% of the total low-ILUC-risk potential.

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Key results from case studies (5)

Eastern Romania (Macroregion 2)

Figure: Production potential for low-ILUC-risk biodiesel from rapeseed: by ILUC prevention measure in the low, medium and high scenario in macroregion 2 in Romania in 2020 compared to the NREAP target for biodiesel for Romania and for macroregion 2 in 2020.



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Key results from case studies (6)

Lublin Province, Poland (Gerssen-Gondelach et al. 2014)

Implementing the ILUC prevention measures would allow realizing a significant bioenergy potential with a low risk of causing ILUC while contributing to climate change mitigation: In total, the bioethanol production potential in Lublin is 13 to 36 PJ per year or 533 to 1,520 million liter per year in 2020 (see figure next page). **This low-ILUC-risk potential of miscanthus-based ethanol from Lublin province (Poland) is 1.4 – 4.1 times the 2020 2nd generation bioethanol target specified in the National Renewable Energy Action Plan (NREAP) for Poland**.

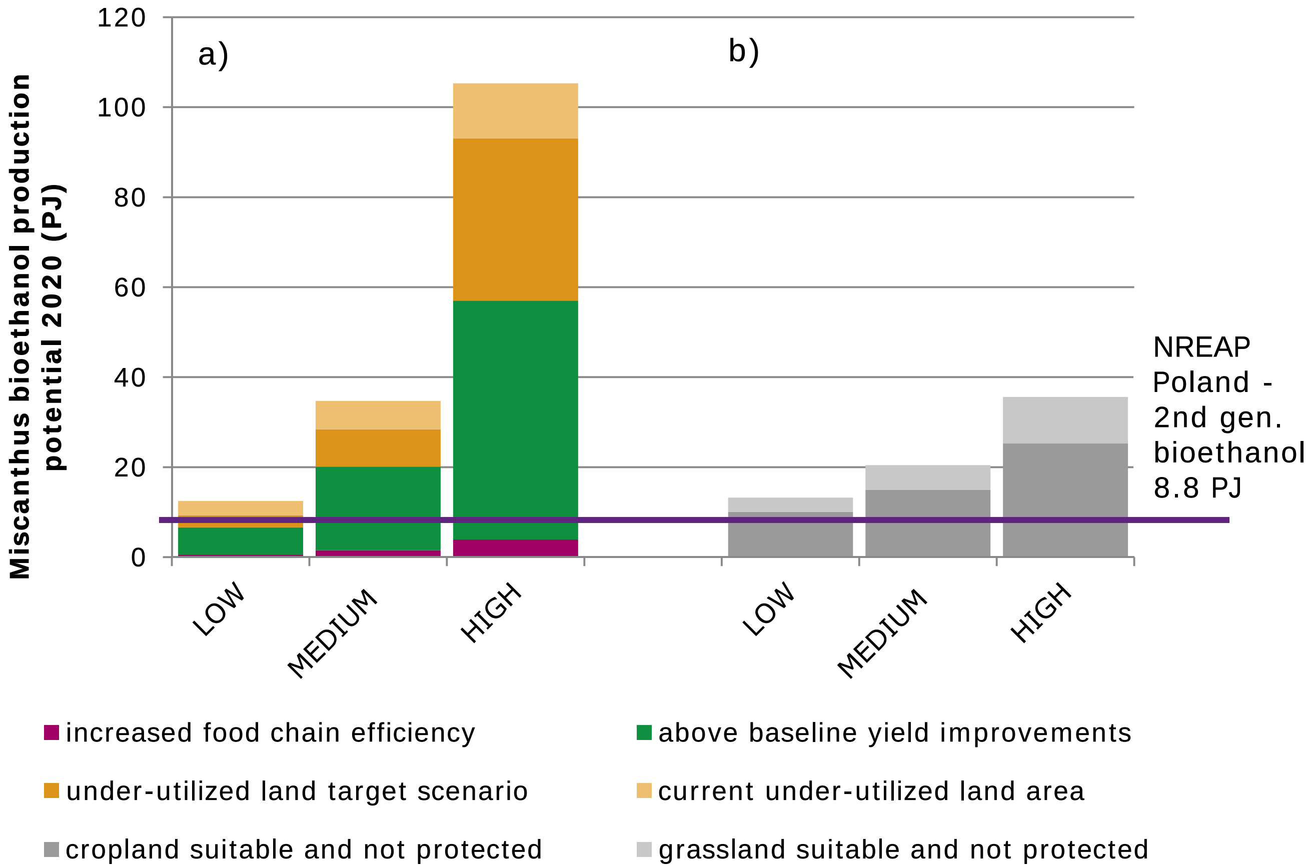
Above baseline yield improvements and land abandoned due to reduced food production can contribute most to this potential. However, in the medium and high scenarios, not all of the total surplus land area is suitable and legally available for miscanthus cultivation (see panel B compared to panel a in figure on next page).

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Key results from case studies (7)

Lublin Province, Poland

Figure: Production potential for bioethanol from Miscanthus: a) on surplus land by ILUC prevention measure in the low, medium and high scenario, and b) on land that is considered to be suitable for Miscanthus production.



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Key results from case studies (8)

North-East Kalimantan, Indonesia (van der Laan et al. 2015)

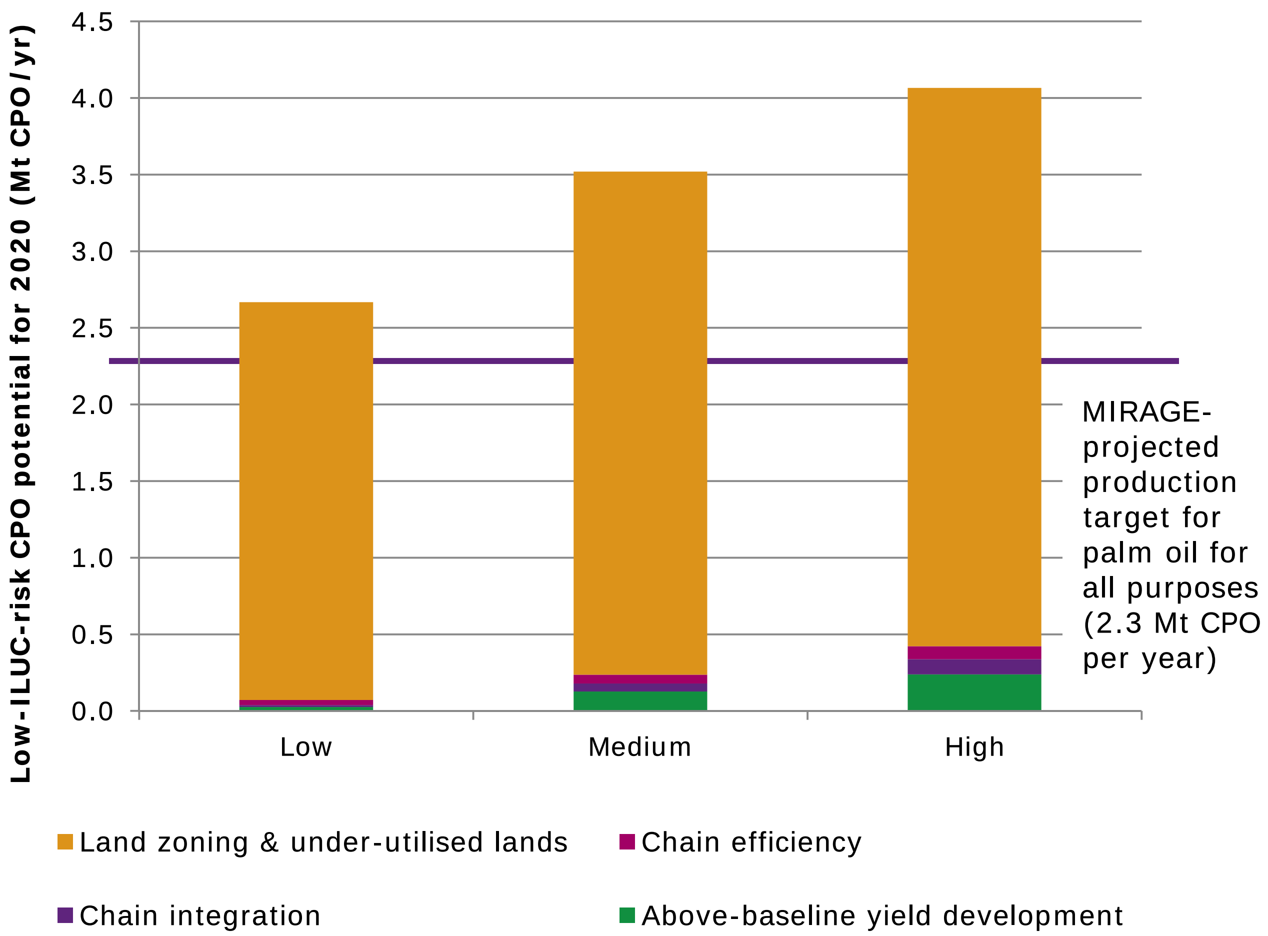
The results from this case study show that between 2.7 and 4.1 Mt crude palm oil (CPO) per year can be produced in North-East Kalimantan with low risk of ILUC. This **low-ILUC-risk potential is 1.2 to 1.8 times the regionally-disaggregated production target of 2.3 Mt CPO per year projected in MIRAGE for 2020**. While in MIRAGE this production target causes large GHG emissions due to land use change (particularly the conversion of forest and peatland forest), we show that this additional production can be made possible without such land use change.

The key measure for generating this low-ILUC-risk potential is using under-utilized land for production, making up more than 90% of the potential. In the analysis, we consider only 40% of the under-utilized land area to be available for palm oil production in order to account for that not all land identified is actually available and suitable. This percentage is based on field assessments for West Kalimantan, where 41% of the investigated sites were unavailable or unsuitable due to e.g. the presence of existing oil palm plantations, culturally important sites, intensive land use and/or extreme flooding (Gingold, 2012). Ground truthing specifically for NE Kalimantan is needed to determine the share of the under-utilized land area actually available in NE Kalimantan.

Key results from case studies (9)

North-East Kalimantan, Indonesia

Figure: Low-ILUC production potential of CPO in North-East Kalimantan, Indonesia. For reference purposes, the current CPO production in NE Kalimantan is 0.4 Mt per year



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Key results from case studies (10)

ILUC prevention is possible in all case studies

In all case studies, unwanted LUC from biofuel targets can be prevented by the proposed technical measures for modernizing and sustainably intensifying the agricultural sector and by using under-utilized land for additional production. Not only is the low-ILUC-risk potential larger than the projected increased demand arising from biofuel targets, it is also larger than the increased baseline demand in most scenarios. Thereby, unwanted LUC from all uses and ILUC from biofuels specifically can be prevented.

Yield increases are a key strategy in all cases

Increasing yields is the most important measure for ILUC prevention in three of the four cases (in the case of North-East Kalimantan, it can also provide a significant low-ILUC-risk potential but is less important than under-utilized land, see next page). Yield increases are not only beneficial for reducing the risk of ILUC, but also for the farmers (particularly smallholders) to increase their income. The case studies showed that technical measures are available to increase the yields above the baseline. However, the implementation of the measures especially for smallholders requires large investments and support (see also policy and governance options). The analysis of increased yields focused on agricultural crops and livestock. Additional measures that can contribute positively are multi-cropping and productivity increases in the forestry sector (specifically forest plantations).

Key results from case studies (11)

Under-utilized land is most important in the case on NE Kalimantan

Use of under-utilized land is also a key measure for preventing ILUC - for the case study on North-East Kalimantan, it is actually the most important one. In the other cases, under-utilized land in the form of abandoned agricultural land can also significantly contribute to the low-ILUC-risk potential.

An important result is that data availability and quality (especially detailed spatial data on where under-utilized land is located and whether it is really available for conversion) is low. Field verification of its availability for conversion and carbon stocks is therefore needed.

In order to ensure that only under-utilized land is used for future conversion to agricultural production, land zoning must be made with detailed spatial and up-to-date data on land use and land cover, excluding high carbon stock, high conservation value and important ecosystem service areas. At the same time, land zoning must be strictly enforced in order to be effective (see also policy and governance options).

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Key results from case studies (12)

Using co-products reduces overall land requirements	Benefits of distillers' grain solubles (DGS) and oilseed meals have already been demonstrated by ILUC studies in the past. This is confirmed here. But our analysis clarifies that the benefits vary depending on how and where these products are used. While DGS can contribute important benefits, compared to above-baseline yield developments and use of under-utilized land, this measure has less impact. We also approximated the benefits of other co-products (such as crop residues, corn oil, palm trunks, palm kernel oil). These can also contribute to the low-ILUC-risk potential. The analysis focused on biofuel co-products, but residues from other crop production could also provide a significant low-ILUC-risk potential (Daioglou et al, forthcoming).
Increasing chain efficiency allows using more of what is produced, thereby reducing overall land requirements	This study focused on crop losses in the production chain. Increasing chain efficiency allows using more of what is produced and thereby reduces overall land requirements. In the case studies of this project, increased chain efficiency only has a small contribution to the low-ILUC-risk potential compared to other measures.

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Key results from case studies (13)

GHG emissions	The analysis of GHG emissions in the biofuel supply chains focused on assessing how and how much the chains can be improved. The key factor in the GHG balance is LUC. In the case of North-East Kalimantan, production of palm oil on previously (primary or secondary) forestland results in more emissions than fossil fuels, while production on under-utilized land can reduce emissions compared to fossil fuels. In the case of miscanthus production in Poland, potentially large soil carbon sequestration can even result in a reduction of GHG emissions with 85% or more compared to fossil fuels.
Best management practices	In addition, the application of best management practices during the cultivation of the biofuel feedstocks can further improve the GHG balance. Although measures vary per case, a key common measure to reduce emissions per biofuel units is optimized fertilizer use in terms of quantity, composition and timing.
Waste streams	For the case study on palm oil in North-East Kalimantan, the treatment of palm oil mill effluents (POME) is crucial for the GHG balance. Treatment in closed anaerobic digesters and collection and combustion of the gas reduces emissions, while it can also serve as a source for electricity generation.

Key results from case studies (14)

Data availability and quality

Data availability and quality was assessed in detail in the case study analyses. Although the low-ILUC-risk potentials can be determined, key constraints by data limitations exist:

1) Spatially explicit data about **actual land use and land cover**: This is needed to assess the suitability and legal availability of (agricultural) land (this is especially important for developing currently under-utilized land) but also to monitor ILUC prevention (see Monitoring).
2) Disaggregated data on **crop yields**: Particularly for the case of North-East Kalimantan, availability and quality of yield data was low. More regionally specific yield data (including ranges), disaggregated for oil palm age classes and by producer type are needed in order to better identify where efforts to increase yields are needed most.
3) Data on **food chain efficiencies:** Existing data on crop losses are often estimated as a fixed percentage of the total available amount of the agricultural product, not always specific per crop, and not spatially detailed enough to determine difference between regions.

Key results from case studies (15)

Scenario analysis

In order to take account of uncertainty in input data and projections and effects on results (as a form of sensitivity analysis), for each measure and case, three scenarios (*low*, *medium*, *high*) for potential developments above the baseline were applied. The scenario analyses are based on the range of values for the key parameters as found in the literature and in discussion with experts. All chosen parameter values are technically feasible and already reached in neighboring regions or comparable settings.

The results show that there **is significant leeway for improvements** but the magnitude of these improvements **depends largely on the level of investment and efforts** made. The implementation in practice may be hampered by various factors. Policy and governance options may help to reduce these barriers, as described in the following.

Policy and governance options (1)

Framework for governing ILUC

This study has shown that ILUC can be prevented if we take a sustainable approach to all crop production for food, feed, fiber and fuels. This means

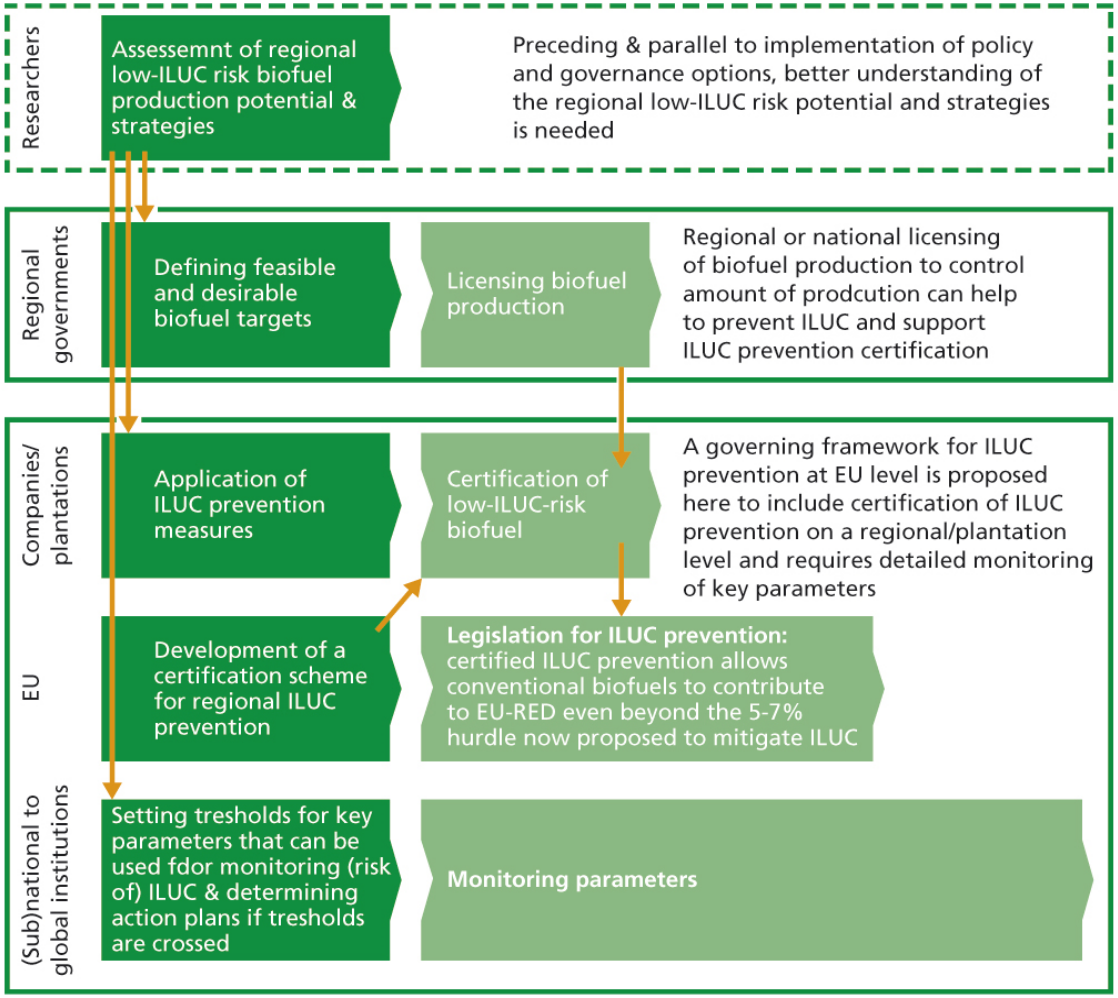
- Increasing productivity and resource efficiency in the production for all of these purposes.
- Appropriate zoning of land for all purposes.

Both a governing framework for ILUC prevention and policies for ensuring a sustainable pathway for biofuels in general need to take a broader and more integrated perspective by i) addressing all land use and ii) stimulating increases in resource efficiency and productivity for all these uses. Such an approach is in line with and supports the European Council Conclusions on 2030 Climate and Energy Policy (European Council, 2014) related to the agriculture and land use sector: "*The European Council invites the Commission to examine the best means of encouraging the sustainable intensification of food production, while optimising the sector's contribution to greenhouse gas mitigation and sequestration, including through afforestation*."

The graphic on the following page illustrates how such a framework could look like based on the regional approach taken in this project.

Policy and governance options (2)

Framework for governing ILUC



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Policy and governance options (3)

Options specific to ILUC prevention measures	The case studies demonstrate that (large amounts of) additional biomass for fuels can be produced without causing ILUC. However, the analysis of these case studies assumes that additional action is taken so that surplus land is generated and only suitable and available under-utilized land is used for additional production (whether for food, feed, fiber or fuels). In order to support and stimulate these actions, policy and governance are needed. Important options per ILUC prevention measure are listed here:
Above baseline yield development	• Knowledge and capacity building (e.g. seed quality; optimal fertilizer use in terms of composition, quantity and timing; machinery; earlier replanting for palm oil) • Support cooperation between smallholders • Improve availability & access to capital, technology and high-yielding seeds • Incentivize investments in the agricultural sector

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Policy and governance options (4)

Production on under-utilized lands & land zoning	• Improve land use, cover & soil information (spatially and temporally detailed) • Make more informed decisions on land zoning • Improve monitoring & enforcement • Incentivize forest maintenance • Additional incentives must be considered to promote the production of biofuel feedstocks on land that is currently under-utilized so that missed opportunities from converting higher quality land or clearing forest are compensated. Certification for using under-utilized land and then receiving a financial bonus on the price of the crop may be such an option.
Improved chain integration	• Research & development for optimal use of under-utilized co-products (in terms of economics, environment & social aspects) • For waste products (e.g. palm oil mill effluent), tighter waste management regulation are needed to reduce environmental impacts of production.

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Policy and governance options (5)

Increased chain efficiencies	• Improve data quality to be better understand where losses occur (crop-specific and by chain components) • Capacity building on reducing pre- and post-harvest losses for producers with high losses (e.g. important for smallholder palm oil producers) • This study focused on crop losses in the production chain. Food waste at households was not included because it involves behavioral changes by consumers and this falls outside the scope of this project. However, in industrialized countries reducing food waste has a significant potential that could contribute to making more food/land available for additional production. Therefore, the extent of food wastage in households and the potential to reduce it need be better assessed.
Lower GHG emissions in the biofuel supply chain	• Capacity building on reducing GHG emissions in chain by e.g. optimized fertilizer usage (timing, frequency, composition and amount) • Waste management regulation (particularly relevant for POME) • Land zoning (excluding high carbon stocks as well as other high conservation value areas)

Monitoring (1)

Improving data availability and quality	Based on the case study assessment of input data described earlier, data availability and quality need to be improved. This is important for reducing uncertainties in the low-ILUC-risk potential but also for monitoring the implementation of ILUC prevention measures and the risk of ILUC itself. The key parameters that require improvement in data and that are useful for monitoring are presented in the tables on the following pages.
Setting thresholds and determining actions plans for the event that thresholds are crossed	For monitoring to be useful and effective in mitigating ILUC, it is important to set thresholds for the key parameters used in monitoring (the risk of) ILUC and to determine action plans for the event that thresholds are crossed. For example, at the moment increased biomass production would lead to crossing pre-determined threshold values on such parameters (e.g. biomass crops clearly expanding at the expense of food crops), further expansion could be halted until improvements in conventional agricultural are expected or proven. Within such a concept, regional parameters that are regularly monitored (partly with public data complemented by audits) and verified to stay within threshold values for sustainable land use and overall biomass production would be a novelty and can in principle become part of certification procedures.

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Monitoring (2)

Table: Key parameters for monitoring *ILUC risk*

Key parameters for monitoring	Purpose for monitoring	Frequency	Spatial scale
- Land use and land cover (remote sensing supplemented with field verification), land ownership	What land use change is taking place and where? Is expansion taking place? And if so, where? Are under-utilized lands taken into production? How much under-utilized land is still available? Who owns the land and how is that changing?	Yearly to twice-yearly	Spatially specific at high resolution
- Agricultural production volume	What crops are produced and at what quantity? Is production developing as projected?	Year (averaged over several years)	Regional to country level
- Trade volumes	No major increase in imports of agricultural products or processed goods? Decrease in soy and other feed imports?	Yearly (averaged over several years)	Country
- Food prices	What are absolute and relative (comparing different crops) food prices?	Monthly to yearly	Country to global

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Monitoring (3)

Table: Key parameters for monitoring *ILUC prevention measures*

Key parameters for monitoring	Purpose for monitoring	Frequency	Spatial scale
- Crop/livestock yields (five year moving average)	Is the yield and yield increase as high as desired? How does the individual yield vary compared to averages?	By cropping seasons/ yearly	Individual farmers to regional to national
- Development of under-utilized land	How much land is under-utilized? What quantity is converted and for what? What are yields? Where is reforestation taking place?	Yearly	Spatially explicit
- Product specific food losses in the supply chain	Where are the losses? How high are the losses? Are they reducing as much as expected?	Continuously	Crop specific at regional/ country level
- Use of co-products	How are co-products used and where? What does it displace and how much?	Yearly	Feed specific at regional/ country level

Conclusions (1)

ILUC can be prevented	Not only is the low-ILUC-risk potential larger than the increased demand due to biofuel targets in 2020, but in most scenarios it is also larger than the projected increased demand from food, feed and fibers. Consequently, **unwanted LUC from all uses and specifically ILUC from biofuels can be prevented**. This is possible by the proposed technical measures for modernizing and sustainably intensifying the entire agricultural sector and by using under-utilized land for additional production.
Most important measures	**Above-baseline yield developments** and **use of under-utilized land** are the most important measures for achieving ILUC prevention. In the Eastern European case studies, increased yields contribute in most scenarios to over 75% of the potential. In the Indonesian case study, use of under-utilized land contributes to over 90% of the potential.
Generalizability of case study results	Although specific case studies were assessed in this project, the results are **also generalizable to the broader regions** in which the cases are located, i.e. Eastern Europe and Southeast Asia. **Other countries in Europe and elsewhere** also have untapped low-ILUC-risk potentials that could be further explored and mobilized (e.g. mixed production systems in Western Europe such as double cropping, pasture intensification in Latin America, yield increases in Africa).

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Conclusions (2)

ILUC is a risk that can be mitigated	Thus, ILUC as determined in economic models is not an irreversible fact, but is a risk that can be mitigated and in some case be prevented.
ILUC prevention has additional benefits	Addressing ILUC by taking a sustainable approach to all crop production has the additional benefits of increasing the performance of the agricultural sector as a whole, reducing the pressure on land by agricultural and forestry, and reducing GHG emissions from the agricultural (incl. bioenergy) supply chains.
Translation of ILUC prevention measures from theory to practice	The technical options for preventing ILUC assessed in this study show a large potential for improvements in the agricultural supply chain and from using under-utilized land, which together lead to a low-ILUC-risk biomass production potential that in all case studies is larger than the projected additional demand for food, feed, fiber and fuels. Translation of the measures from theory to practice is needed. This is possible through pilot projects.

Conclusions (3)

Pilot projects (Key aspects for pilot projects)

Pilot projects for demonstrating the approach and for monitoring are the next step to validate the concepts. Pilot projects can help provide insights into the different considerations that need to be made with regard to implementing, certifying and monitoring ILUC prevention measures. Key aspects for pilot projects are:

- Comparing publically available data with monitoring and ground truthing in the field in order to assess the reliability of existing, statistical data.
- Assessing to what extent uncertainty in the analysis can be reduced by improved data quality and whether the additional time and money needed for (field) data collection are acceptable and appropriate for the improvements.
- Translating ILUC prevention measures to implementation and monitoring in practice. A link with certification schemes is useful for making ILUC prevention verifiable (e.g. in collaboration with the LIIB project, van de Staaij et al. 2012).
- Making a risk assessment of a particular region and defining their specific strategies for ILUC prevention.
- Assessing how quickly the ILUC prevention measure proposed in this study can be implemented, at what costs, and what practical hurdles and challenges for implementation at farm and regional level are.

Policy Recommendations (1)

A governing framework for ILUC prevention is needed	Both, a governing framework for ILUC prevention and policies for ensuring a sustainable pathway for biofuels in general need to take a broader and more integrated perspective by i) **stimulating increases in resource efficiency and productivity for all these uses** and ii) **addressing all land use**. Both of these are goals defined in the European Council Conclusions on 2030 Climate and Energy Policy (European Council, 2014), which promotes sustainably intensifying food production and optimizing the sector's contribution to greenhouse gas mitigation and sequestration.
Legislation on ILUC mitigation	Given the i) large low-ILUC-risk potential found in this study, ii) applicability of the results to other regions, and iii) additional ILUC prevention options in the case studies and other regions, legislation on ILUC mitigation should consider including **more ways to mitigate ILUC than just capping first generation** biofuels. **Certifying low-ILUC-risk biofuel production** as assessed in this study and allowing its **contribution to the renewable energy target** is proposed here as the key option to mitigate ILUC. For this, a sustainable approach to all crop production for food, feed, fiber and fuel purposes is crucial.

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Policy Recommendations (2)

Taking a sustainable approach to all crop production for food, feed, fiber and fuel purposes in order to prevent ILUC, specific recommendations from this project are:

Promote land zoning	• Promote **land zoning** that excludes high carbon stock, high conservation value and important ecosystem service areas from conversion to any use, particularly outside of Europe. This is a key element in making commodity production more sustainable. This may also include support for enforcing land zoning and incentivize forest maintenance.
Use under-utilized land	• Provide (financial) incentives for production on **currently under-utilized land**.
Increase productivity and resource efficiency	• Stimulate increasing **productivity and resource efficiency** in the agricultural sector through support and incentives schemes, incl. increasing access to capital and technology, and capacity building.

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Appendix – Method for quantifying ILUC prevention (1)

Methodology described in detail in Brinkman et al. (2015a)

The method used to analyze and quantify the ILUC prevention measures in terms of their low-ILUC-risk potential is described in detail in the methodology document prepared for this project (Brinkman et al. 2015a). In the following, an overview of the key aspects of the method are given:

- Selection of crops and livestock
- Production volumes
- General aspects of ILUC prevention
- ILUC prevention measures
  - Above-baseline yield developments of crops
  - Above-baseline yield developments of livestock
  - Chain integration
  - Chain efficiency
  - Under-utilized land for biofuel production and land zoning
  - Reducing GHG emissions in the biofuel supply chain
- Analysis integration

Appendix – Method for quantifying ILUC prevention (2)

Selection of crops & livestock	For each case study, an overview of the most important crops in terms of areal extent and their share in total agricultural land in the region is made. Based on this overview, those crops are selected that together cover at least 75% of the total arable land, depending on the case study. With regard to livestock production, the importance of the livestock sector in the case study region is assessed by parameters such as the area of land under pasture and meadow, livestock population, and current production of milk and beef. Poultry and pigs are not grazing animals and are mainly fed with processed feed. The land use (change) related to this feed is already taken into account by assessing agricultural crops. Cattle production is closely related to the use of meadows and pastures. Thus, the area of meadows and pastures that can become available for bioenergy production mainly depends on changes in cattle production.

Appendix – Method for quantifying ILUC prevention (3)

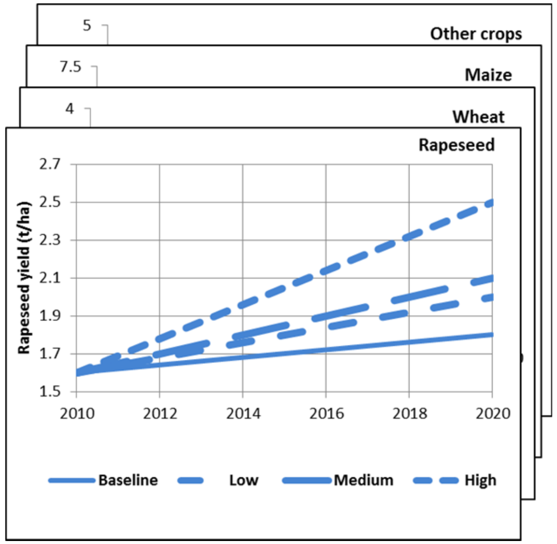
Projected production volume	The projected production volume in the case study in 2020 is determined by disaggregating the projected production in the world region (from MIRAGE) to the case study region based on the current share of crop production in the case study compared to the world region. If livestock cattle production makes up a significant user share of land, also the projected production in 2020 needs to be assessed. However, the production for beef and milk in 2020 cannot be derived from the MIRAGE model. Therefore, the projected production is derived from extrapolating the historical trend line.

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Appendix – Method for quantifying ILUC prevention (4)

Above-baseline yield developments - Crops

1. Assess yield developments of all major crops of the region
2. Determine 2020 production volumes per crop from MIRAGE projections – fixed for baseline and above-baseline yield developments
3. Calculate surplus land area through increases in crop yields, i.e. the difference between the area needed for producing the crop production volumes set in step 2 in the baseline yield scenario (as determined by MIRAGE) and the above-baseline yield scenarios (as determined in step 1).
4. This surplus area and projected biofuel crop yield are used for assessing the low-ILUC-risk biofuel crop production potential.

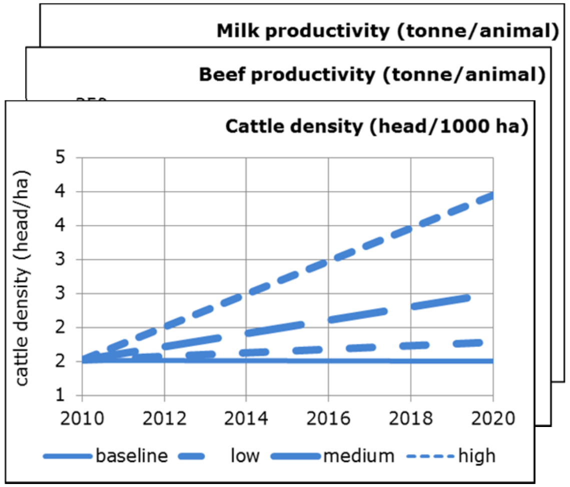


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Appendix – Method for quantifying ILUC prevention (5)

Above-baseline yield developments - Livestock

1. Assess developments in cattle density and livestock productivity
2. Determine 2020 milk and beef production volume based on recent trends in case study region (as MIRAGE does not provide physical volumes for livestock)



3. Calculate surplus land area through increases in cattle density and beef and milk productivity, i.e. the difference between the area needed for producing the production volumes set in step 2 in the baseline productivity/density scenario and above-baseline productivity/density scenarios (step 1).
4. This surplus area and projected biofuel crop yield are used for assessing the low-ILUC-risk biofuel crop production potential.

Appendix – Method for quantifying ILUC prevention (6)

Chain integration

When co-products from the biofuel production chain are integrated in the agricultural production system, the replaced products do not need to be produced anymore and the land can be used for production of biomass for energy.

Consequential analysis –as used in life cycle assessment- is applied to determine the reduction in production of the crop that is replaced and the corresponding amount of land that is needed.

Steps in the calculation:

1. Assess the increased availability of co-products based on projected increased production (incl. additional biofuel production from surplus land generated in other measures).
2. Calculate reduction in feed and other crop production in the target scenario.
3. Calculate surplus land available for biomass production.

Appendix – Method for quantifying ILUC prevention (7)

Chain efficiency	Reduced losses in the production chain between agriculture and households reduces the demand for agricultural crops. As a consequence less land is needed for the production of these crops. This leaves more land available for the production of biomass for energy. Steps in calculations: 1. Establish current losses in food and biofuel chain. 2. Determine potential reduction in losses in food and biofuel chain by assessing the sources of losses and comparison to other regions. 3. Calculate reduced losses of production in the target scenario. 4. Calculate surplus land available for biomass production.

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Appendix – Method for quantifying ILUC prevention (8)

Biofuels production on under-utilized land & land zoning

Under-utilized lands include set-aside land, abandoned land, degraded land, marginal lands and other land that does not currently provide services, i.e., “unused lands” (van de Staaij et al. 2012). This land can be used to cultivate extra biomass for bioenergy. In some cases, this land is less productive than existing agricultural land and then a marginal yield factor is applied in assessing the potential production on this land (based on literature and expert opinions). But not in all cases, the yields are actually lower.

Land zoning helps avoid the conversion of land with e.g. high carbon stocks, biodiversity or other ecosystem services to biofuel feedstock production. Land zoning is often combined with the measure on under-utilized land in order to define what is under-utilized and when is it available for conversion. However, it can also be important when surplus land generated from ILUC prevention measures is not currently legally available for biomass production for energy purposes (e.g. in some areas in the case study on Lublin province (Poland), food crops are allowed to be produced but energy crops are not. This comes despite the fact that some energy crops can actually benefit the soil and biodiversity levels compared to food crops.

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Appendix – Method for quantifying ILUC prevention (9)

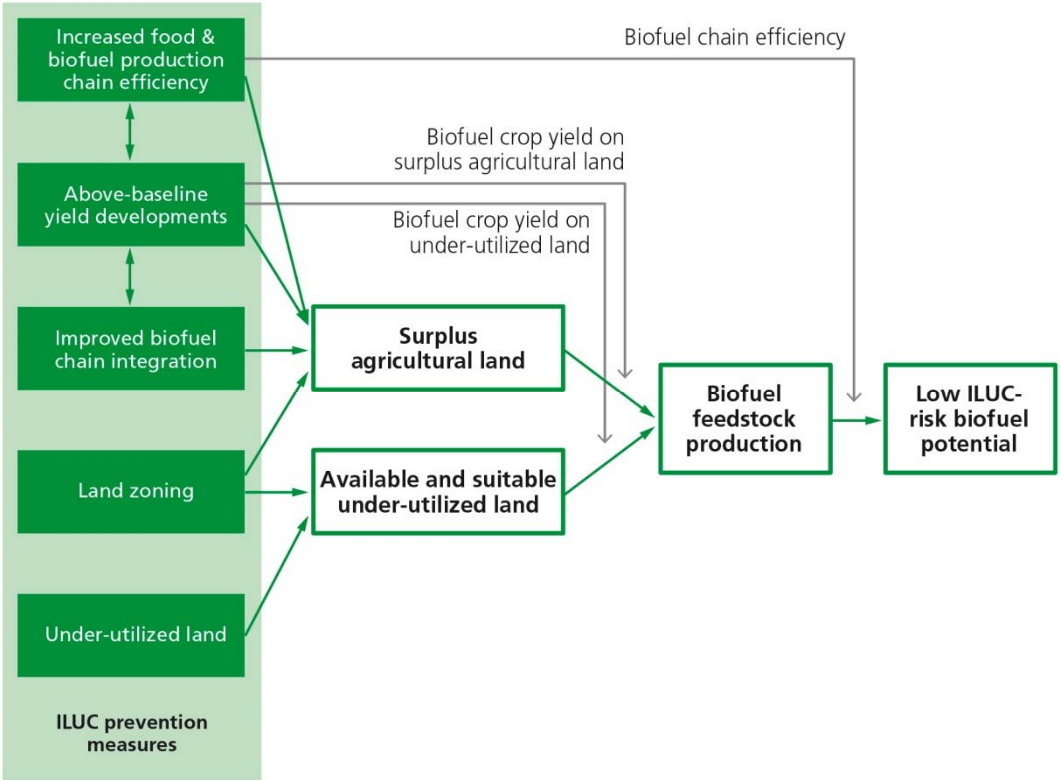
Reduced GHG emissions	Lower GHG emissions in the biofuel value chain help to increase the GHG emission reduction potential of biofuels compared to fossil fuels. To assess possibilities for GHG mitigation, first GHG emission data for the biofuel supply chain is collected from literature. Key data to be included are: • direct land use change, including soil organic carbon changes due to cultivation • fertilizer management in the crop cultivation (type and amount of fertilizer) • consumption of fossil energy during crop production (e.g. due to use of machinery) • transportation method(s) and distances • GHG emissions from feedstock conversion and credits from co-products • biofuel end-use (e.g. transport to refueling station) Then, the data are combined into a low and high GHG balance. Based on these two balances, potential GHG mitigation strategies in different parts of the value chain are identified and discussed. These could, for example, include best management practice with regard to tillage and fertilizer use, improved yields, and reduction or capture of emissions from waste streams. Finally, the GHG balances are compared to the GHG emissions of fossil fuels to give an indication of GHG Emission savings.

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Appendix – Method for quantifying ILUC prevention (10)

Integrated analysis

Figure: Integrating the different measures accounts for the interactions and feedback between different measures.



Key interactions (continued on next page)

- Reducing food losses decreases the food production volume required for supplying the same amount of food. As a result, above baseline yield developments result in lower surplus area.

Appendix – Method for quantifying ILUC prevention (11)

Integrated analysis - Interactions between measures

- Using co-products from the biofuel supply chain more optimally reduces the production of crops that are substituted by the biofuel co-product. The crop yield determines how much land is saved.
- Above baseline yield developments in existing food, feed and biofuel production result in surplus agricultural area when projected demand is met. The biofuel crop yield is then used to assess how much low-ILUC-risk biofuels can be produced on the surplus agricultural land and under-utilized land. For the assessment of the potential on under-utilized land a potentially lower yield on under-utilized land compared to surplus agricultural land is considered.
- The improvements in the chain efficiency for food and biofuel production result in making surplus land area available for biofuel feedstock production. The biofuel chain efficiency is also used in the conversion of feedstock to biofuel low-ILUC-risk potential.
- Land zoning helps avoid the use of land with high carbon stocks, biodiversity or other ecosystem services for biofuel feedstock production. Land zoning is often combined with the measure on under-utilized land in order to define what is under-utilized and when is it available for conversion.

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